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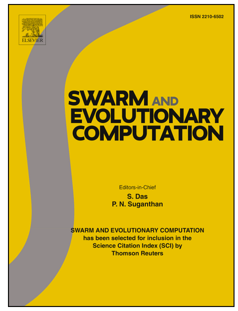

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Handling Time-Varying Constraints and Objectives in Dynamic Evolutionary Multi-objective Optimization

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Abstract

Recently, several researchers within the evolutionary and swarm computing community have been interested in solving dynamic multi-objective problems where the objective functions, the problem's parameters, and/or the constraints may change over time. According to the related literature, most works have focused on the dynamicity of objective functions, which is insufficient since also constraints may change over time along with the objectives. For instance, a feasible solution could become infeasible after a change occurrence, and vice versa. Besides, a non-dominated solution may become dominated, and vice versa. Motivated by these observations, we devote this paper to focus on the dynamicity of both: (1) problem's constraints and (2) objective functions. To achieve our goal, we propose a new self-adaptive penalty function and a new feasibility driven strategy that are embedded within the NSGA-II and that are applied whenever a change is detected. The feasibility driven strategy is able to guide the search towards the new feasible directions according to the environment changes. The empirical results have shown that our proposal is able to handle various challenges raised by the problematic of dynamic constrained multi-objective optimization. Moreover, we have compared our new dynamic constrained NSGA-II version, denoted as DC-MOEA, against two existent dynamic constrained evolutionary algorithms. The obtained results have demonstrated the competitiveness and the superiority of our algorithm on both aspects of convergence and diversity.

Keywords: Dynamic multi-objective optimization, time-varying constraints, time-dependent objectives, evolutionary algorithms.

1. Introduction

Dynamic Multi-objective Optimization Problems (DMOPs) involve the simultaneous optimization of several objectives subject to a number of constraints where the objective functions, constraints and/or problem parameters may vary over the course of time. Dealing with such problems impose several challenges. In fact, the optimal Pareto Front (PF) and the optimal Pareto Set (PS) may change over time. Moreover, as the constraints are also time-dependent, the feasibility area would not remain unchanged. Such complex dynamic behaviors make the task of optimization more difficult. Therefore, solving constrained DMOPs needs to handle essentially the following issues: (1) evolving a near-optimal and diverse PF, (2) preserving the required diversity to ensure a high level of adaptability, and (3) ensuring a good trade-off between feasible and infeasible solutions to converge towards simultaneously, feasibility and optimality.

Evolutionary Algorithms (EAs) have been used to solve DMOPs, where their earliest state of the art application to dynamic environments dates from 1966 [1]. However, this subject has not gained a significant attention until the 1980s. A number of approaches have been suggested such as diversity introduction-based approaches [2], change predictive approaches [3, 4, 5], memory-based approaches [6, 7], parallel approaches [8], and approaches that convert DMOP into multiple static Multi-objective Optimization Problems (MOPs) [9]. The majority of these works focused only on unconstrained problems. Nevertheless, in real world, we usually confront problems that not only need to optimize a number of conflictual goals but also have a set of constraint conditions to be satisfied. Referring to the literature, despite the increasing interest for the use of EAs to solve DMOPs, their application to the constrained ones is not yet largely explored [10]. Encouraged by the significant importance of dynamic constrained optimization problems in practice [11] and by this lack of attention on solving constrained DMOPs using EAs, in this paper:

- we develop a new *self-adaptive penalty function* that, in addition to feasible solutions, it makes use of infeasible solutions having high fitness values in an effective and efficient manner. This helps increasing population diversity and avoiding to be trapped on local optimal PFs;
- as constraints are also time-dependent, we propose *a feasibility driven strategy* that we apply at each change detection. This strategy is able to guide the search towards the new feasible regions according to environment changes; and

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